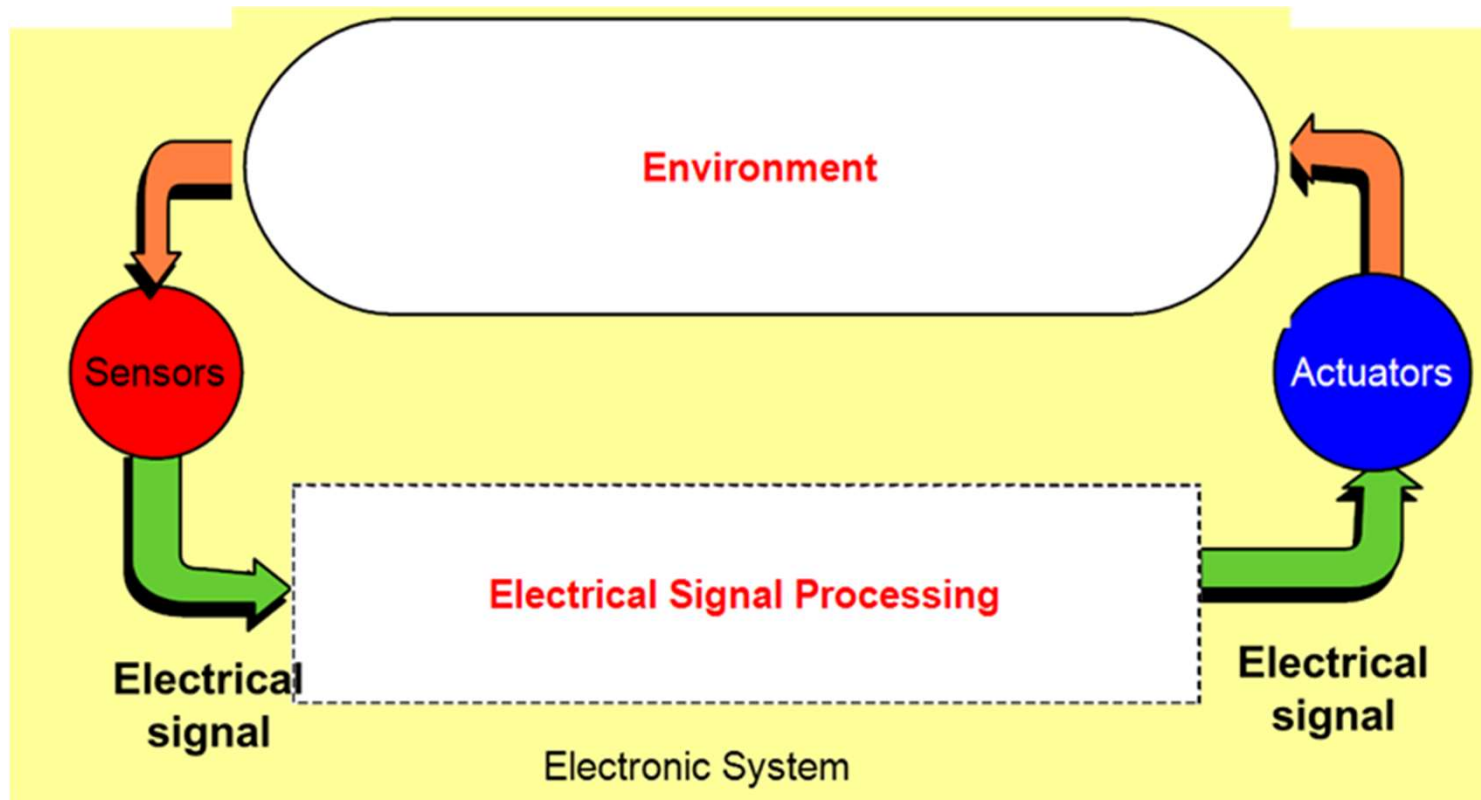


ESC201AT : Introduction to Electronics

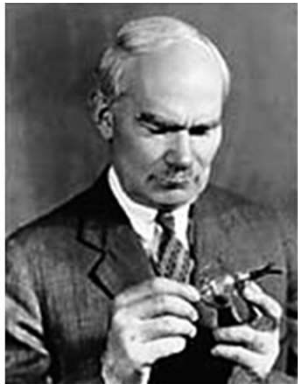
Lecture-2 : A Historical Perspective

B. Mazhari
Professor, Dept. of EE
IIT Kanpur



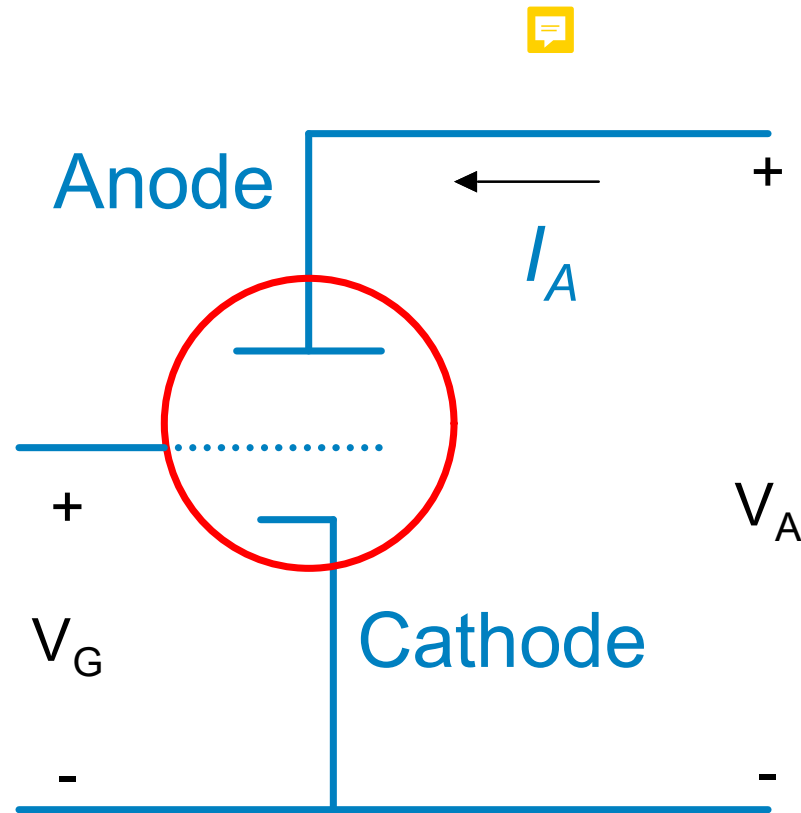
Solve Problems by transforming them
to Electronics Problems

The Electronics revolution started with the invention of the Triode (1906)



Lee De Forest : 1873-1961

Grid



Transconductance

$$\frac{\partial I_A}{\partial V_G}$$

Output conductance

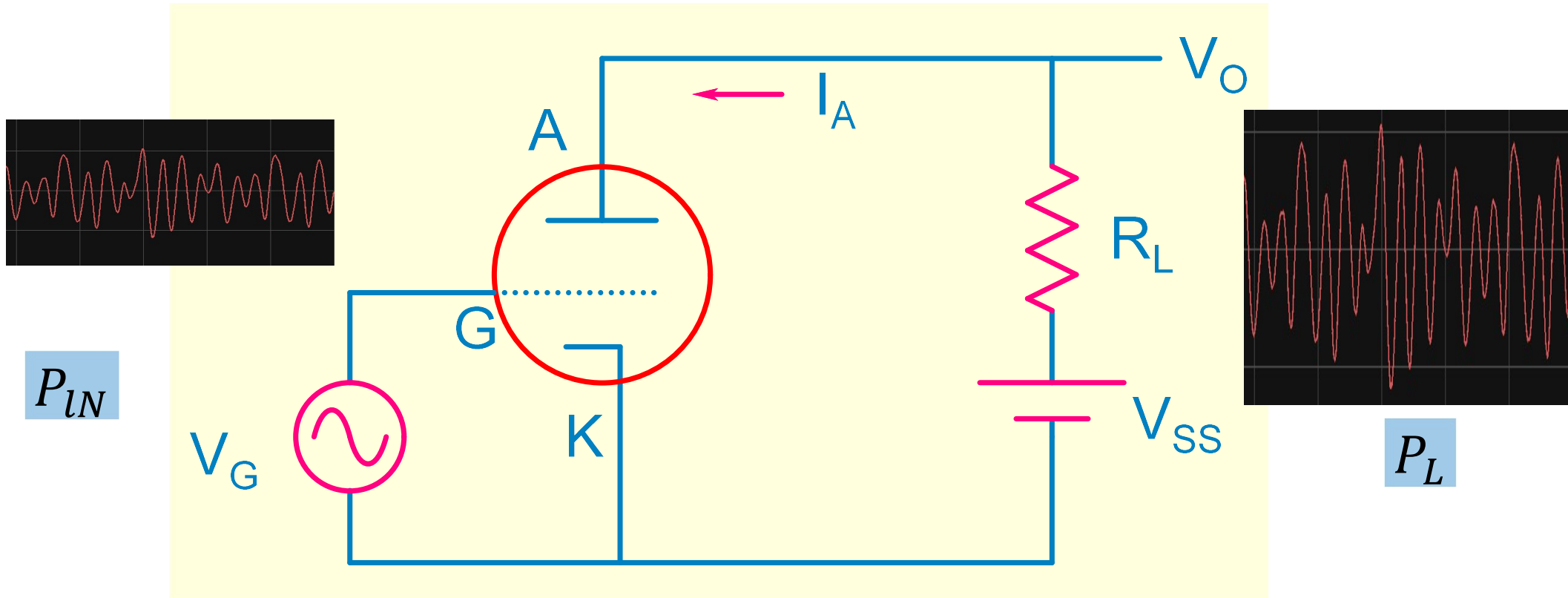
$$\frac{\partial I_A}{\partial V_A}$$

$$\frac{\partial V_A}{\partial V_G} \gg 1$$

$$\frac{\partial I_A}{\partial V_G} \gg \frac{\partial I_A}{\partial V_A}$$

Amplifier

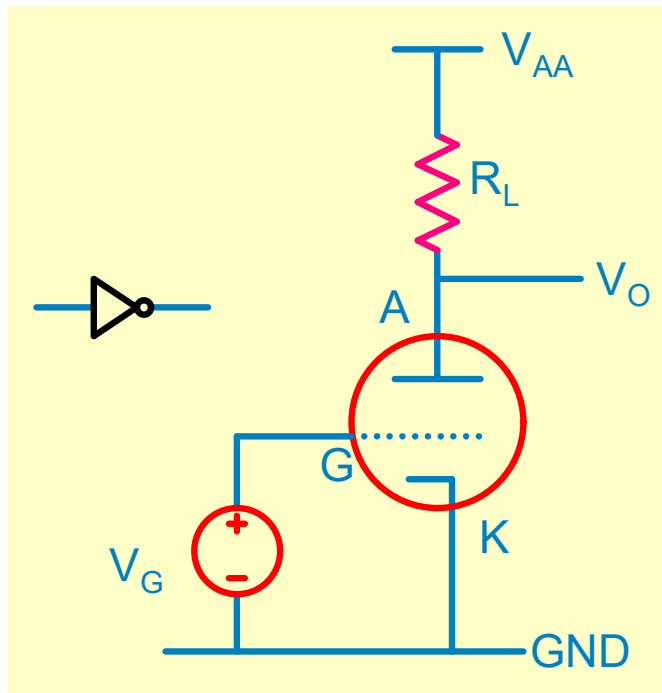
Communication was revolutionized



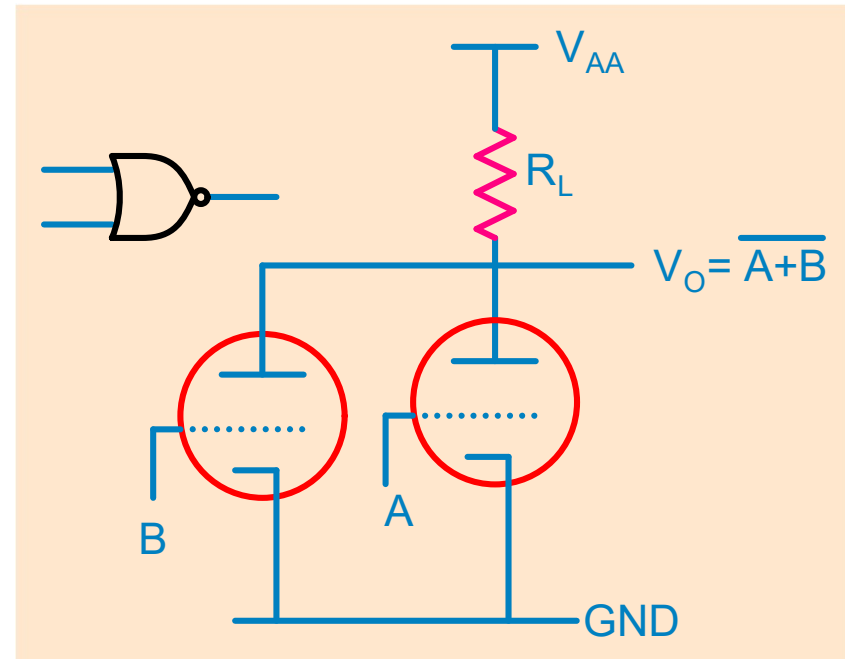
$$P_L \gg P_{IN}$$

$$P_L - P_{IN} = P_{SS}$$

Triode revolutionized information processing

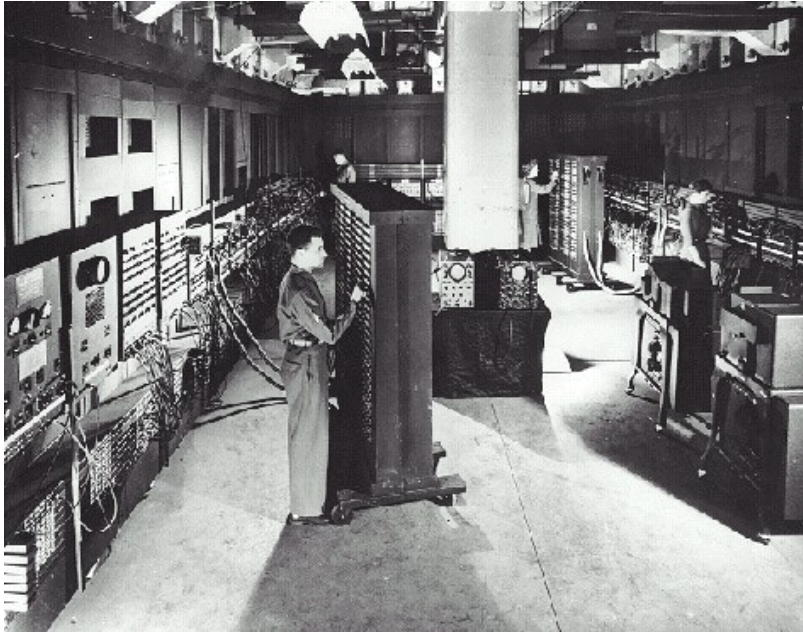


Inverter



NOR Gate

For almost 50 years Electronics was based on vacuum tubes



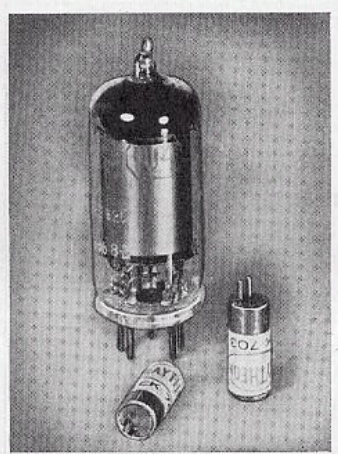
30 x 50 feet room

ENIAC: Electronic numerical Integrator and computer: 1946

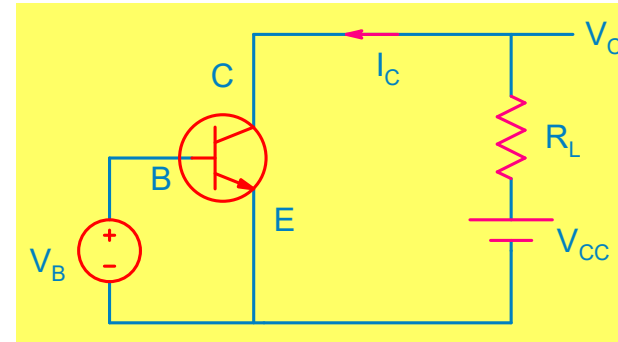
The ENIAC contained 17,468 vacuum tubes, along with 70,000 resistors, 10,000 capacitors, 1,500 relays, 6,000 manual switches and 5 million soldered joints

It weighed **30 tons**, consumed **160 kilowatts** of electrical power,
Records from 1952 show that approximately 19,000 vacuum tubes had to be replaced in that year alone, which averages out to about **50 tubes a day!**

Transistor: 1948



Two CK703 germanium crystal triodes shown with a 1U4 tube for size comparison.



$$\frac{\partial I_C}{\partial V_{BE}} \gg \frac{\partial I_C}{\partial V_{CE}}$$

$$\Rightarrow \frac{\partial V_{CE}}{\partial V_{BE}} \gg 1$$

A Transistor could do most of what a triode could do and it was smaller, consumed less power and was more reliable

What occupied a room earlier, now occupied a table top



-530 germanium transistors and 2300 diodes.

-Size 420 x 440 x 250 mm (16.5" x 17.3" x 9.8"), 25Kg

-Cost 535 thousand yen (about US\$1,490)

-90 Watts of power

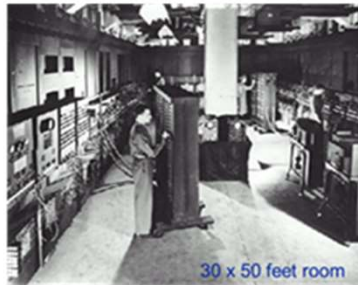
Sharp CS-10A, 1964

Complexity of Integration was better but still limited



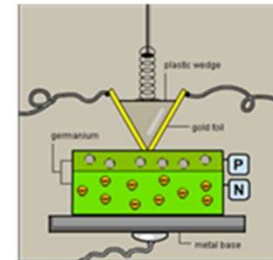
1906

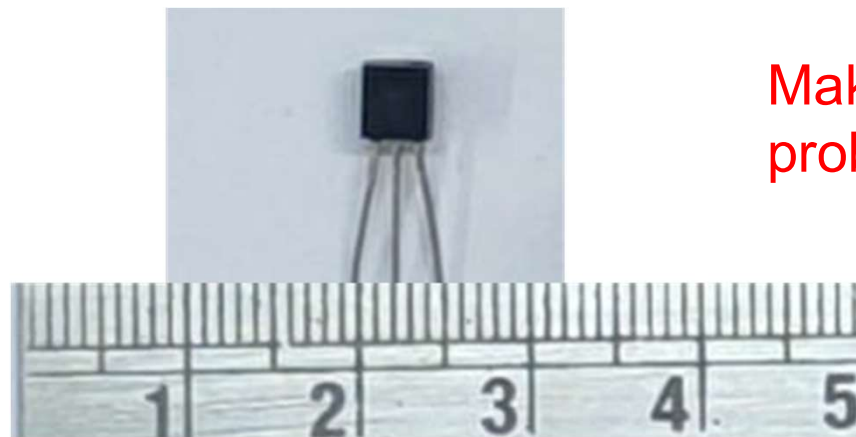
Vacuum tube
Electronics



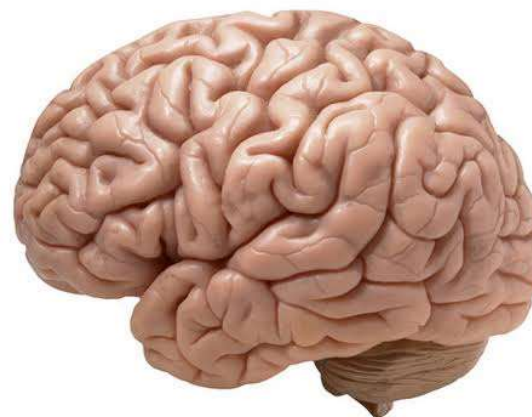
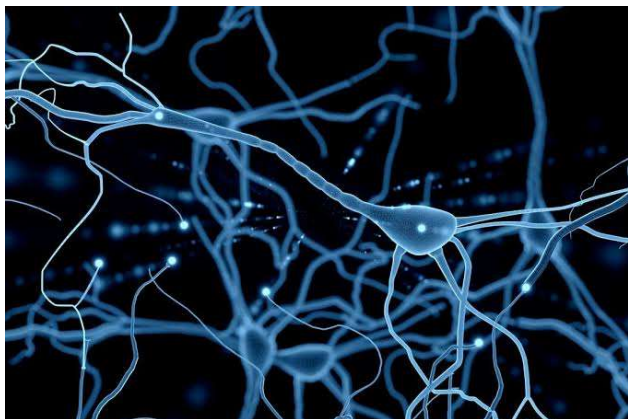
1948

Bipolar Tr. Based
discrete circuits

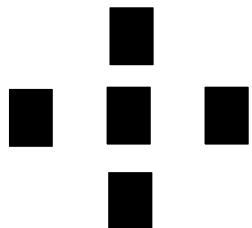
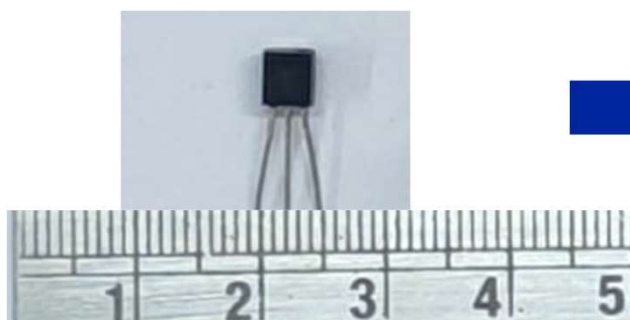




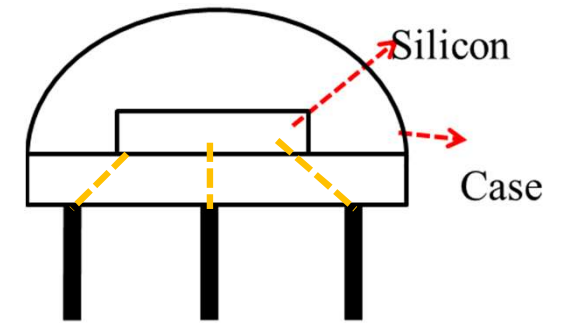
Making complex circuits is a problem !



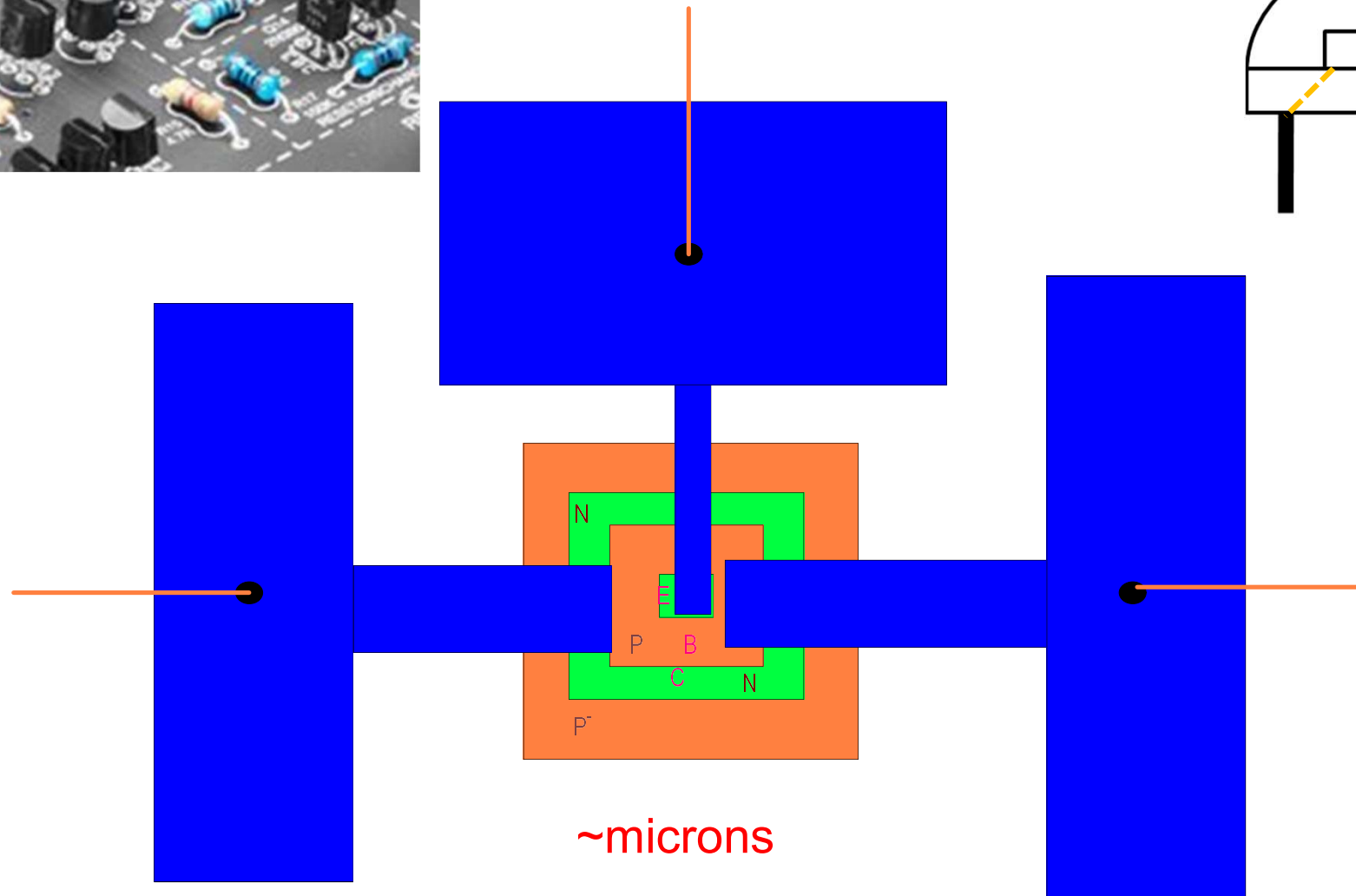
Billions of Neurons



$\sim 1 \text{ Tr} / \text{cm}^2 \rightarrow 10^3 \text{ cm} \times 10^3 \text{ cm}$
for 10^6 Tr. Circuit

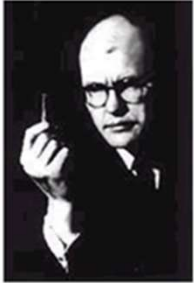


~ cm



~microns

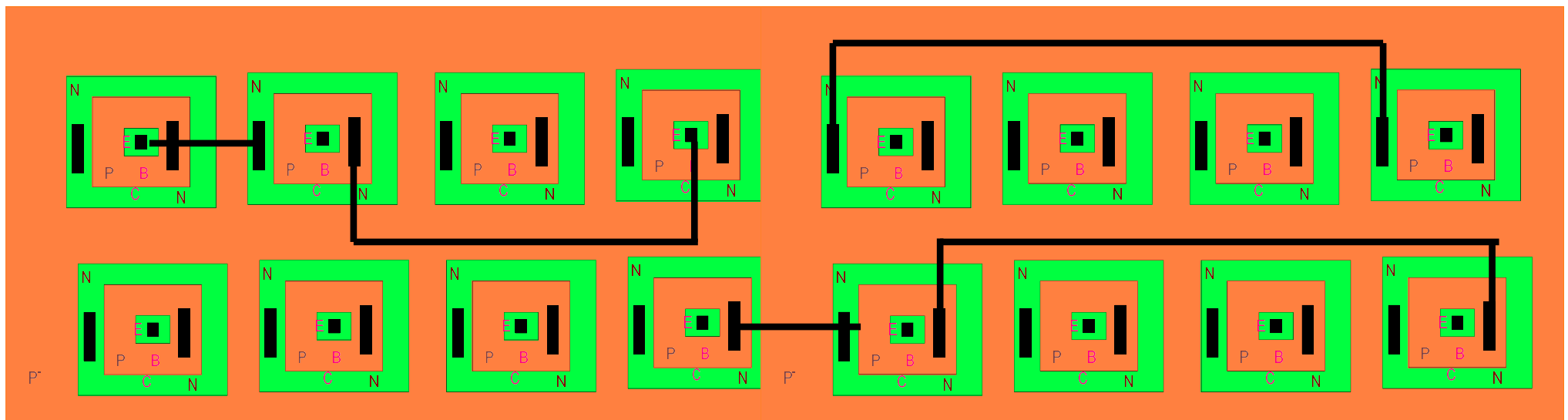
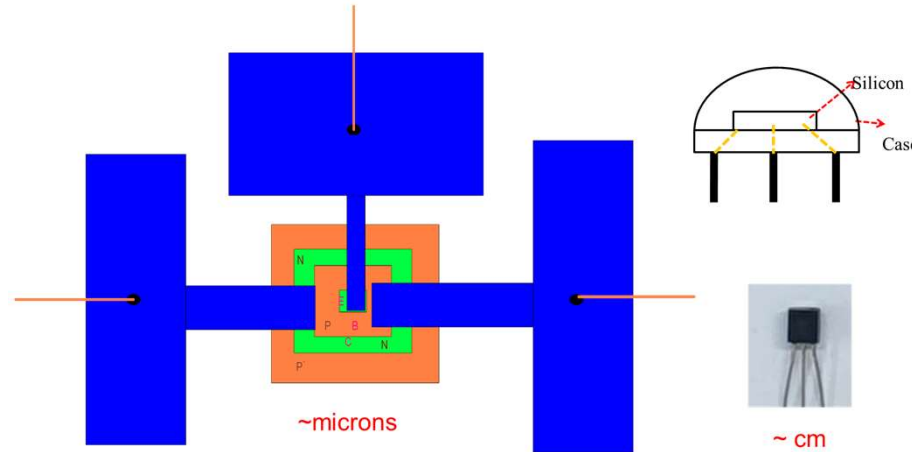
Transistor led to a new method of manufacturing: Monolithic Integrated Circuit



Jack Kilby



Robert Noyce





Jack Kilby

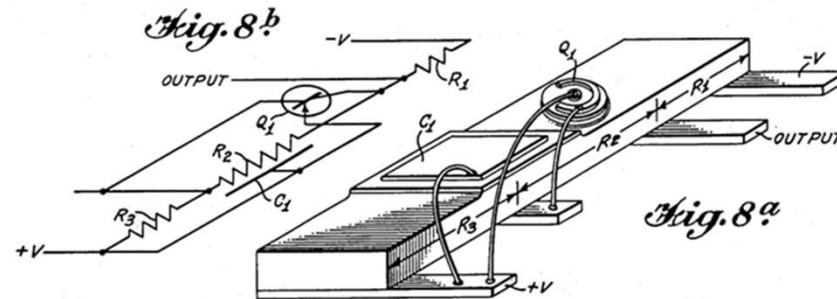


Fig. 8^a

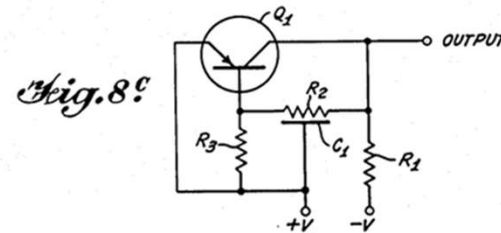
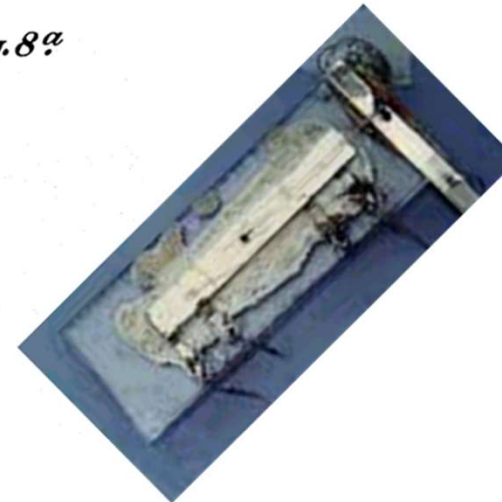
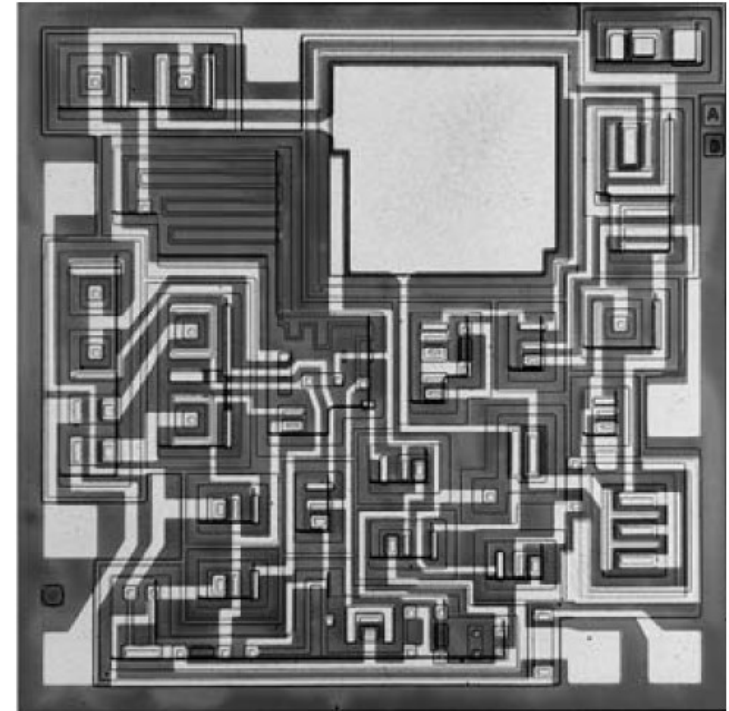
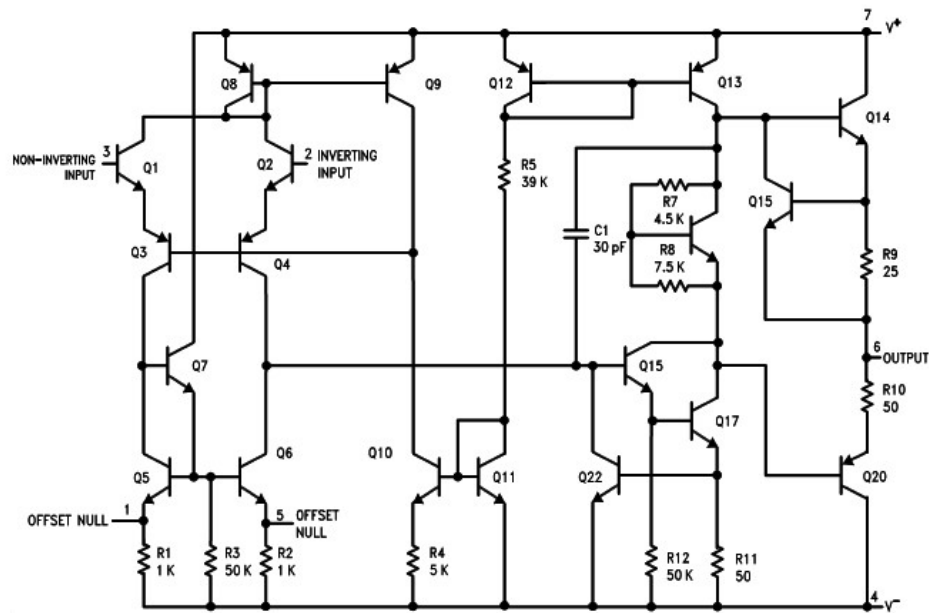


Fig. 8^c

Jack S. Kilby
INVENTOR

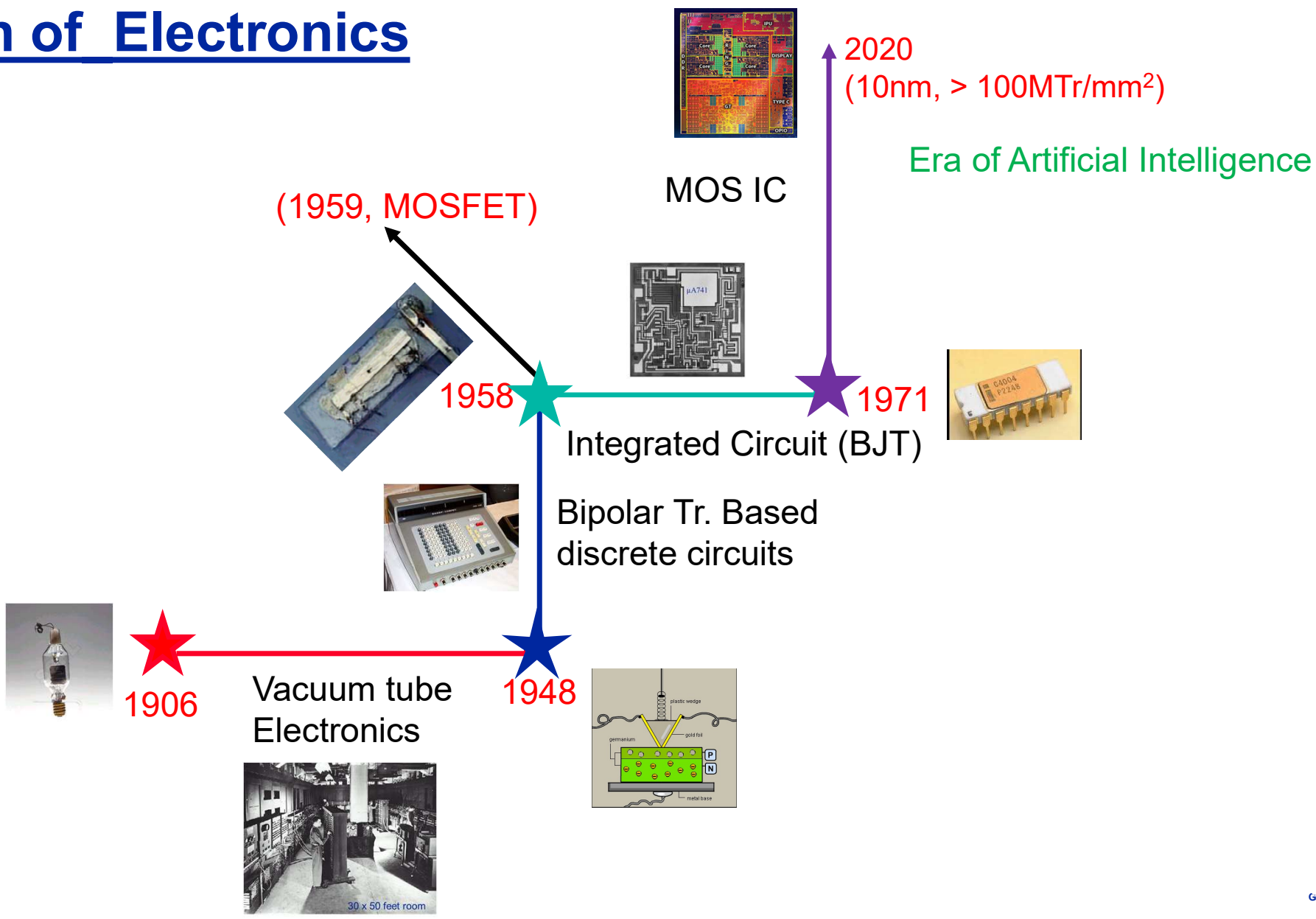


case may be, between diffused regions. According to the principles of this invention, all components of an entire electronic circuit are fabricated within the body so characterized by adapting the novel techniques to be described in detail hereinafter. It is to be noted that all components of the circuit are integrated into the body of semiconductor material and constitute portions thereof.



Advantages : Density, reliability, cost,...

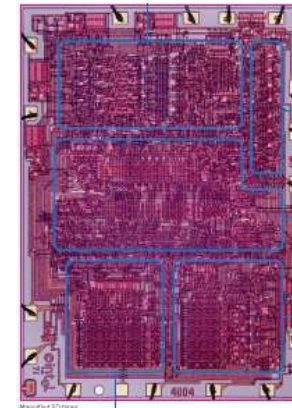
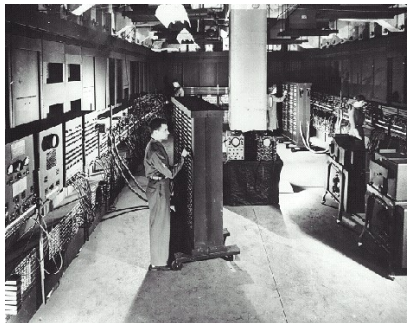
Evolution of Electronics



Nobel prize in 1956



Nobel prize in 2000



Increasing Complexity of Circuit